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AUTHOR Salomon, Gavriel
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ABSTRACT

Researchers in the field of instruction are exploring the theory that different instructional procedures may be used for students with varying aptitudes so as to individualize teaching, so-called aptitude-treatment interactions (ATI's). This paper reviews pertinent literature, then seeks to develop theoretical models for the generation of aptitude-treatment hypotheses for general teaching situations. Three models are discussed. In the remedial model, the instructor attempts to provide some missing, but necessary building-block of knowledge, by identifying a specific deficit. In the compensatory model deficiencies are not corrected, but circumvented so that subsequent learning may take place. The third model involves preferential treatment which seeks to capitalize on other talents of the students to countervail any learning deficit. (RB)

Heuristic Models for the Generation of Aptitude-Treatment Interaction Hypotheses

Gavriel Salomon
The Hebrew University of Jerusalem
Israel

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Researchers in the field of instruction are becoming more amenable to the idea of aptitude treatment interactions (ATI) as opposed to the search for the one "best" method or instructional treatment. In fact, the number of studies in which ATI's are deliberately sought after is increasing rapidly. Yet, ATI research still seems to work on the basis of trial and error. Many would agree with Cronbach and Gleser (1965) that aptitude information is useless in adapting instruction unless aptitude and treatments interact. However, no conceptual tools have been developed so that specific ATI's can be either theoretically interpreted, or deduced from a rationale. Shulman (1970 a) comments that "ATI's are likely to remain an empty phrase as long as aptitudes are measured by micrometers and environments by divining rod." Brach's summary (1970) only corroborates Shulman's statement. In his summary of ATI studies, Bracht found only a handful of them to be of much value. Many of them were simply uninterpretable.

ATI research can be perceived as accomplishing two functions. The first is a rather pragmatical one, namely: improving instruction. ATI work differs in this respect from traditional research on instruction by admitting the existence of individual differences and taking them into consideration. It is based on the assumption that different instructional procedures may lead to the same learning outcomes in interaction with aptitudes. This is the view emphasized by Cronbach (1967).

However, instruction cannot expect to gain very much from this approach due to numerous reasons. One of them is that any given group of learners can be divided along numerous, uncorrelated lines. Consequently, numerous types of alternative instructional procedures may be developed. Moreover, learners can be subdivided to receive different curricula, to receive the same curriculum along different structural lines or to be given material along the same structural line but through different modalities, etc. ad infinitum.

Quite possibly, the only practical way to assign students to different curricula, contents, modalities, rates of presentation and the like, is to use computer based instruction along the lines developed by Stolurow (1967)[1] .

The second function which ATI research can accomplish is the development of better explanatory principles concerning the nature of instruction. The need for more conceptualization, to reduce the very high"degree of empiricizm" prevailing in research on instruction is generally acknowledged. Some (e.g. Cronbach, 1966) see this as the most practical approach on the long run.

ATI research, by gradually constructing a matrix of learning situations and lerners' characteristics, may facilitate the development of a theory of instruction. But to do so one needs to be able to group learners who are similar along some meaningful lines vis à vis instructional situations which are also grouped along such lines (Cronbach and Snow, 1969). Generating ATI data which does not suggest any explanatory principles, or which is not aimed at formulating them, has relatively little practical value or theoretical import.

In the typical ATI study, an instructional treatment is taken as a complex package which ought to benefit some learners more than others. At the same time an alternative treatment is designed and expected to have the converse effect. This latter treatment differs however, from the former only in terms of its operational procedures. There is very little in the way of rationale that explains what psychological functions determine treatment effectiveness for one group of learners and not for another. Thus, for instance Tallmadge, and Shearer (1969) interpret the results of their ATI study, in which either an Inductive or a Deductive method of instruction was given to Navy enlisted men, as follows:

> "The difference between meaningful rules and arbitrary rules is only one of many differences which existed between the Transportation Technique and Aircraft Recognition subject - matter areas. Any of these differences could have been responsible for the reversal relationships between learner characteristics and instructional methods." (p. 228)

In other studies, two treatment are designed and a large number of aptitude measures tossed in with the hope that some may lead to an ATI. Fortunately enough, some measures actually lead to ATI's, but still no explanatory conceptual scheme emerges.

One attempt at inducting a general descriptive principle from available ATI studies was done by Cronbach and Snow (1969). Based on the ATI's found by Stalling and Snow (unpublished), Koran, Snow and McDonald (1971) and Salomon and Suppes (in press), Cronbach and Snow have suggested that treatments which force subjects to attend to and to differentiate among details benefit low general ability subjects. The reason being that such treatments compensate for the subjects' deficient attentional and discrimination skills. The high ability subjects, on the other hand, do relatively poorly on these treatments, perhaps because these treatments place too great an emphasis on the details of the material. These subjects do far better when treatments require rapid manipulation of symbolic meaning, probably a preferred mode of operation for them.

A second attempt at formalizing some conceptual heuristcs for ATI's (Snow, 1970) was in some ways an extension of the above. Two models were suggested: A compensatory model, where treatments serve to do for the learners that which the learners cannot do for themselves, and a preferential model, where the treatments call upon the learner's high aptitude.

In the present paper we wish to expand, formalize and further develop the previously suggested heuristics. More specifically, three "models" of ATI are offerred. These seem to suggest three different sets of answers to the following questions:

(a) What do treatments do to learners that can lead to ATI's?
(b) What kinds of aptitude measures will interact with what kinds of treatments? and
(c) What kinds of predictions follow from each of the suggested heuristic models?

It will become clear that the three models are complementary. Each refers to a different domain of treatments and aptitudes. No claim is made for exhaustion. That is, treatments may and most likely do accomplish more functions than the three dealt with here. However, it is felt that by describing these three heuristic models, attention will be drawn to the explanatory potential which resides in them or in similar ones.

(1) The Remedial Approach

The first of the three models is the most commonly practiced one. One often speaks of remedial programs, make-up courses, etc. The assumption made is the same in all: some critical ingredient of knowledge is deficient or missing, and no progress in learning can be expected unless the deficiency is overcome. Consequently, some kind of remedial instruction is called for to close the gap. Underlying this approach is a hierarchical conception of knowledge, of learning, and consequently also of instruction. It is closely associated with the work of Gagné, Ausuble and others.

For Gagné instruction is the piecemeal addition of knowledge. Knowledge becomes organized into increasingly more complex hierarchies of capabilities. Through his method of task analysis he defines an objective and then asks: What is it that the learner

needs to master prior to that, and in what order should it be given to him, so that there will be maximum vertical transfer. Or, alternatively: What would the learner have to know, and in what order of acquisition in order to be able to achieve a certain task, given only instruction? The basic element in this approach is that the learner begins as a blank slate: what is learned is an imprint of cumulative effects by experience (Shulman, 1970 b). Learning is basically connective and cumulative. As Gagné puts it: "The child progresses from one point to the next... He learns an ordered set of capabilities which build upon each other in a progressive fashion" (1968, p. 181). Moreover: "... each of them (the capabilities) is also learned under different internal conditions, the most important of these being what the individual already has available in his memory" (p.182).

Two implications for ATI grow out of this view. First, the most important differential measures which can interact with treatments are tests of highly task-specific achievement (Gagné and Gropper, 1965). More general measures are not seen, within the framework of this approach, as having the potential of interacting with treatments. The reason for this is embedded in Gagné's general view, namely, that so called general abilities are themselves composed of subordinate capabilities. The latter can be learned. Once mastered they lead up to a more general capability such as, say, "conservation" or even "reversibility". This, to an extend, agrees with Wholwill's new formulations of Piaget's theory (1970) and with his experimental findings.

The second implication concerns consequently the provisions made for individual differences on task-specific capabilities. Examples of such provisions are the time devoted to an instructional

unit within a hierarchy of objectives, the number of remedial units, and the like; Gagné points out (1968) that the ordered structures underlying the attainment of specific objectives are not a universal necessity. And yet, in practice an analysis of subordinate capabilities will generally yield only one hierarchy of objectives and only one "preferred" teaching program (Shulman, 1970 b). For all practical purposes, instructional treatments will differ from each other only in terms of time, specificity, repetitions, etc. but not in terms of modalities, content structure or method of presentation. If variations of the latter type are introduced they are not meant to lead to an ATI. The treatment designed for the low aptituder, i.e. the one with deficient subordinate task specific mastery, is a remedial one. It makes up for his deficiencies by exposing him to more of the same kind of treatment.

There is little, if any, specific data to demonstrate the model, and little experimental evidence is needed to show that ATI is implied here. The pay-off function, in terms of cost and energy is reduced when unnecessary remedies are provided. For another, there are factors of boredom, reduced motivation and interference which become critical when remediation is unnecessary.

This approach, although a bit oversimplified here for the sake of brevity, seems to be in line with the recent views on "learning for mastery" (Bloom, Hastings and Madaus, 1971). Also there the aptitudes expected to interact with alternative instructional treatments are, as Carroll suggests (1963), task specific capabilities. Treatments, similarly, differ mainly with respect to length of instruction, number of tutorial sessions, and the like. When a more general ability is found to correlate with learning outcomes (e.g. ability to understand instruction) it is turned into an instructional subordinate objective -- as part of the general hierarchy -- and remedial instruction to improve it is often recommended.

Three recent studies of our own (Salomon, in press) shed some light on the last point and on the psychological nature of remediation. The first major question asked in the three studies was whether learners can imitate and internalize certain schematic operations modeled through filmic techniques. It was hypothesized that learners can learn to perform <u>covertly</u> such operations as "zooming in" on details in a visual display, thus improve their ability to attend to details in a visual display, and differentiate them, as a result of exposure to films which model this operation. Similarly, it was expected that learners become better visualizers of spatial transformations as a result of exposure to films which model the laying out of solid objects. Both kinds of visualization were known from previous studies to underly the attainment of certain superordinate objectives. The question thus became whether these subordinate visualization capabilities can be treated as instructional objectives to be mastered through filmic modeling procedures. The second major question asked was how do such treatments interact with one's initial specific mastery of the trained-for capabilities, when compared with treatments in which the learners are required to provide the necessary visualizations covertly and on their own.

Both types of treatments were found to improve the specific capability trained for. However, significant interactions emerged when learning outcomes were regressed on aptitude measures. It was found as expected, that when learners are "spoon fed" with an externalized representation of the covert visualizations they ought to activate on their own, mainly the poor aptituders benefit. These who can activate the visualizations on their own tend to experience interference. On the other hand, providing no external remediation

and asking the learners to reach criterion on their own, benefits mainly those who have already mastered the necessary subordinate capabilities. (See Figure 1)

Insert Figure 1 about here

In these studies, necessary task-specific capabilities were turned into instructional objectives. Training for them accomplished the function of remediation, and only those who have not mastered them previously benefited from such training. The other experianced interference. This is very much in line with the findings of Bruner (1961), Jensen (1967) and others.

The model described above has however, its limitations for it can describe and predict ATI's only when (a) Task specific capabilities actually account for a large portion of the variance in the learning outcome; (b) The learning material is hierarchially ordered, and (c) all the subordinate objectives on the hierarchy are learnable as a function of instruction. Flieshman and Bartlett (1969) point out that task specific capabilities account for a large portion of achievement variance only in relatively late phases of learning a skill. Early phases however, correlate higher with more general aptitudes, which are not dealt with in the remedial model. Moreover, in certain learning tasks general psychological states (e.g. anxiety, n achievement) play a major role in distinguishing between successful and less successful learner. The remedial model does not seem to apply to such cases either. Providing highly anxious learners with remedial instruction would not affect the cause of their failure, i.e. it would not lead to much improvement. The compensatory model, discussed below appears to be more appropriate in such cases.

The compensatory model

Sieber (1969) had subjects who showed different amounts of anxiety, solve certain chess-like problems. She hypothesized that the debilitating effect of anxiety on problem solving is mediated by memory of intermediate steps: highly anxious Ss do not recall well intermediate steps they take and thus repeat their errors. Two treatments were designed: regular problem solving and problem solving accompanied by visual memory supports. The results showed a strong tendency towards an interaction between treatments and anxiety. Similar results are reported by Wicklegren and Cohen (1962) who used as an aptitude measure their subjects' memory capacity. Stolurow (1964) found that while learning from randomly ordered items in a programmed text favored the more generally able students, the less able ones learned most from a well structured program. He concluded that the latter program did for the poor learner what the better ones could do for themselves.

It becomes clear that in these studies the treatments interact with aptitudes for reasons other than making up for deficiencies. Apparently, the treatments "compensate for each learner's deficiency by providing the mode of presentation that the learner can not provide for himself'" (Snow, 1970, p. 76). Note the difference between this model and the previous one. In the former one tries to "fill-in" gaps within the limits of specific performances. In the latter the deficiencies are actually left untouched, and only their debilitating effects circumvented. The assumptions underlying the presently discussed model differ from those underlying the previous one. Here it is not assumed that all relevant capabilities need to be mastered or that they are easily modifiable. Changes in anxiety, memory, spontaneous utilization of verbal mediations, etc. are not necessarily instructional objectives although they may correlate highly

with learning outcomes. Therefore treatments are designed to circumvent their debilitating effects without trying to improve them. Berliner (1970) tested the learning of prose under two conditions: the text plus Test-Like-Events inserted in it every few minutes, and the text with instructions to take notes. While the latter condition worked well for high scorers on a memory test, the former worked best for the low scorers (Figure 2). These learners, it appears, could hold only small amounts of information in storage and the test-like-events compensated for this deficiency by decreasing the need for storage of much information.

Insert Figure 2 about here

A remedial model, if one tried to apply it in this case, would require a treatment which improves the learners' memory capacity rather than neutralize its effect upon learning.

Interactions emerge because the act of compensation is redundant, or even interfering in the case of these learners who can provide the necessary mediators of their own (Jensen, 1967; Gentile, Kessler & Gentile, 1969). This resembles the rationale behind the remedial model. Therefore the predictions concerning ATI which can be drawn from this model do not appear to differ from those drawn from the previous one. In both cases, it seems, too much spoon feeding, and too much redundancy are not well suited for the high aptituders. However, this similarity in prediction is more apparent than real. The fact is that entirely different aptitudes are used and treatments of different natures are given. There is little overlap (or for that matter, disagreement) between the two models: they apply to entirely different cases. In the case of the remedial model -- highly task-specific capabilities are used while in the compensa-

tory model the aptitudes are of a more general nature. In the former the capabilities are to be changed through instruction while in the latter model they are not. The decision to use either model as a guideline is based on the amount of variance in learning outcome accounted for by the task-specific capabilities in contrast to more general aptitudes. In addition the choice between the two models is also based on the decision whether the subordinate capability, should one be identifiable, is to be trained for or compensated for.

(2) The Preferential Model

When an instructional treatment is designed to match certain students' capabilities it may be designed to make up for deficiencies (the first model) or to circumvent them (the second model). It may, however, also try to capitalize on what the student is already capable of doing. It exploits available strong points in the student's characteristics. Such an approach is based on matching the requirements of the treatments to one of the learner's higher aptitudes (Snow, 1970). It is "preferential" in the sense that the treatment plays to the learner's preferred style or information processing strategy.

An instructional treatment calls for a large number of different information processing operations. Some, e.g., encoding the message, retreiving previously stored information, etc. are quite common to all treatments. Other operations are less common and can be varied. A treatment can utilize various modes of presentation, style of rewarding, way of structuring the material, etc. Thus, it may be made to capitalize more on one, or more on another style of processing information, type of motivation or way of perceiving the environment. In a general sense, an instructional treatment is designed to call upon these kinds of style or aptitude with which a learner is best equipped.

French (1958) found an ATI between two kinds of motivation ("achievement" and "affiliation") and two respective kinds of feedback to students. Ss who were more achievement oriented were found to learn more when achievement feedback was provided and less when affiliation feedback was given. The exact converse was found with Ss who were high affiliation-motivated. Davis and Phares (1969) found that Ss with more internal locus of control searched for and utilized more information when they thought that arriving at a solution depended on skill. Ss with more external locus of control searched for and utilized more information when convinced that a correct solution was a matter of chance. Many additional studies, demonstrating this model can be found in the literature concerned with programmed instruction or other media (e.g. Snow & Salomon, 1968). The ATI suggested by Jensen (1969) is also based on such a preferential model: Level I learners, as he suggests, should be taught along associative lines while Level II learners should be taught along mediational ones. King, Roberts, and Kropp (1969) report ATI results which also fit this model. The hypothesized that Ss high on an inference test should profit more from a deductive teaching method, while high scorers on a Word Grouping Test should learn more from an inductive method. Their results supported their expectations.

The aptitudes which are mentioned in the context of the preferential model, are not the same as those discussed in the context of the remedial model. The essential difference is in the generality of the aptitudes involved in the interaction. Unlike the remedial model, the present one calls for abilities in the sense described by Fleishman & Bartlett (1969), i.e. abilities

which are seen as representing a class of "mediating processes," and which manifest consistencies over tasks. This is to be distinguished from skills, which are more closely related to task-specific capabilities of the kind mentioned by Gagné. In this sense, the present model is closer to the compensatory model than to the remedial one. Yet, the logic of "matching" differs from that of "compensation," and thus yields different predictions (Snow, 1970).

For a treatment to be in some kind of essential agreement with the critical information processing capabilities of a learner it needs to call upon those kinds of mediating processes which he performs best. These, however, are by their very nature rather general. Cognitive styles are perhaps a prime example. Practically, this model suggests that when treatment 'A' is found to correlate with an aptitude of type 'a', it is necessary to find what the low 'a' scorers are better able to do. Hence, it is a search for an aptitude which correlates negatively with aptitude 'a' and consequently also with learning from treatment 'A'. Only then is it possible to design an alternative to treatment 'A' which will call into use the aptitude that low 'a' scorers are more able at.

This is what Gagné and Gropper (1965), Brach (1969) and King, Roberts and Kropp (1969) tried to do. In these studies treatments were devised, one of which played on the verbal modality and the other on the visual modality. ATI's were expected in which the more verbally capable Ss would profit most from the verbal treatment and the more visually capable ones - from the visual. Results, though, were disappointing. Apparently the

treatments were neither verbal nor visual enough. Thus, the verbally-able Ss could use their high aptitude to process the critical information even in the visual presentation, and the visually-able Ss could use visual abilities in the verbal presentation. If a treatment is to correlate highly with an aptitude it needs apparently to let the critical information require this aptitude. Kuhlman (reported by Bruner, et al, 1966) had two groups of children: high and low scorers on an imaginery test. Imagery was measured by a number of tests, thus indicating a rather general style or tendency. Kuhlman found that high imagery scorers performed best when they had to associate arbitrary verbal labels with pictures. The low imagery scorers (and very likely high verbal scorers) excelled in a task which required the formation of a more general concept, based on the shared attributes of pictures.

In all these cases a compensatory model could have been utilized: instead of the visual treatments for the high visual (Low Verbal) scorers, the treatment could have provided -- ready made -- the verbal mediators which the Ss could not supply on their own. If the compensation was strong enough, the ATI that could emerge would be the opposite of the one generated by a preferential model. This can be best illustrated by two studies of our own. In one study (Salomon & Suppes, in press), Ss were either trained to attend to minute stimulus details or to generate alternative hypotheses, using the same stimuli. These training procedures were expected to improve epistemic behavior differentially. That is, low verbal reasoning scorers were expected to profit more from cue attendance training and high scorers - from the hypothesis generation treatment (Figure 3).

Insert Figure 3 about here

The results supported the expectations, showing a case of matching according to the preferential model. In a later study, Ss were given either a list of ready-made cues to attend to, or a list of ready-made hypotheses to test, showing all of them the same stimuli. The dependent variable was, as before, the Ss' epistemic behavior. No training was given. It was reasoned that the treatments compensated for the deficiencies of the Ss. The author hypothesized that providing ready-made details should benefit mainly the higher aptitude scorers who had difficulties generating original hypotheses (Figure 4).

Insert Figure 4 about here

The emerging ATI was in the expected form. Comparison of the two studies shows the opposing nature of the two models. It may be concluded that when treatments provide the mediators that the low aptituder can not provide for himself, they debilitate learning or performance of the high aptituder. On the other hand, when treatments are designed to capitalize on one's stronger aptitudes, the higher aptitudes benefit more.

The preferential model can be extended to other cases in which treatments do not just capitalize on particular information processing operations, but provide an amount of stimulus variability or complexity which is within the learners' information processing capacity. This is still a case of the preferential model in the sense of taking into consideration the learner's channel capacity, tolerance for ambiguity or ability to handle uncertainties (e.g. Mussinger and Kessen, 1968). Two studies attest to this. Clark and Salomon (1971)

found an ATI between scores on Rokeach's Dogmatism scale and two conditions differing in the number of choice alternatives. High Dogmatism Ss were found to engage in search for new information under the two choice condition as much as did less dogmatic Ss with eight choices. The two choice condition which led the high D scorers to search for more information than the low D scores, entailed little uncertainty, but just enough to stimulate information search by the high D Ss. Not so the eight-choice condition. There the effect was reversed (Figure 5).

Insert Figure 5 about here

Marshall (1969) had two groups of Ss: Of "poor" and of "rich" educational environments. A simple learning paradigm (learning of color labels in a P-A like task) was used, and two instructional conditions were given: A high-interest condition which entailed novelty and surprise, as conceived by Berlyne, and a dull condition. The high-interest condition entailed what we might call elements of uncertainty while the so-called dull condition contained only the most relevant information presented in a straight forward manner. The results showed a disordinal ATI: The Ss from the "poor" educational environment outperformed the ones from the "poor" background under the dull conditions (Figure 6).

Insert Figure 6 about here

In both studies it was the amount of psychological strain generated by each treatment which matched the Ss' capabilities. In the study by Clark and Salomon, little uncertainty agreed best with the high D scorers' information processing capacity. In the Marshal study it was the more "interesting" treatment which succeeded in

arousing the necessary curiosity of those Ss of "poor" educational environment. The principle operating in both cases is the same.

In sum, there is one feature which clearly distinguishes between all the models mentioned. While both the remedial and the compensatory models deal mainly with deficiencies, the preferential model deals with well developed capabilities.

Summary and Discussion

It becomes quite clear that of the two intersecting regression lines in an ATI, it is the negative line which is of most interest and importance. What does the treatment do to learners so that low aptituders benefit from it more than high aptituders? And given a certain aptitude which correlates positively with a treatment, of what nature should the alternative treatment be? As we have tried to show there are a number of possible answers to these questions. When it is given that treatment A correlates positively with an aptitude measure 'a', which is perhaps only a measure of one's mastery of the preceding learning objective, then an alternative remedial treatment is called for. Its function is to "make up" for the lack of mastery of the necessary prerequisites. No compensation seems appropriate because the attainment of the objective is conceived of as a necessity. However, when the best predictor of learning from treatment 'A' is a more general ability or psychological state, which by itself is either too difficult or too costly to modify, a compensatory treatment seems appropriate. Finally, if those with low scores on the relevant aptitude are found to be strong on another, yet potentially relevant aptitude, the preferential model is called for. The major attributes of these three models are presented in Table 1.

Insert Table 1 about here

This description is obviously idealized. Seldom do instructional treatments accomplish only one clearly defined function. A treatment may provide a remedy, i.e. "make up" for a deficiency while capitalizing on other well developed characteristics of learners. This is for instance what the Chicago Group did (Bloom et al, 1971) with one of its selected university courses. The researchers supplemented remediation with small group instruction and other special treatments. Nevertheless, it was the make-up instructional treatment which was the major feature while the supplemented methods played a secondary role.

Similarly it is conceivable that a treatment can compensate for a deficiency but do so in a way (or through a sensual modality) which matches best the learner's more general style. This for instance was the case in Koran, Snow and McDonald's study (1971). Teachers Low on the Hidden Figure Test and high on Filmic Memory learned better when exposed to a video taped model as compared with a written one. It stands to reason that the video taped model compensated "for deficiencies in some perceptual processing or analytic skill... through explicit, concrete presentation of stimulus elements" (p. 226). However, this kind of compensation was appropriate mainly for those subjects who had also high filmic memory. The treatment, though compensatory, played to another strength of the subjects. The written model on the other hand, compensated for the deficiency of the low memory subjects, providing them with enough opportunity to rehearse the material. But it worked best with high Hidden Figure Test scorers on whose high analytic ability it played.

The fact that instructional treatments appear very often to accomplish more than one function does not reduce the need of clarifying these functions. We do not claim to have exhausted either the list of possible functions that treatments can accomplish, or the list of possible explanatory rationales for ATI's. But since, as

Cronbach and Snow (1969) maintain, ATI's cannot be based solely on superficial similarities between learning tasks and aptitude measures, heuristic models of the kind presented here appear to have some reasonable value.

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Figure Captions

Figure 1: A Case of Remediation: Training on Subordinate Capabilities (Salomon, in press).

Figure 2: A Case of Compensation: Test-Like-Events and Note Taking Interact with Memory (Berliner, 1970).

Figure 3: A Case of the Preferential Model: Cue-Attendance and Hypothesis Generation Training Interact with Verbal Reasoning Ability. (Salomon & Sieber-Suppes, in press).

Figure 4: A Case of Compensation: Providing Ready-Made details or hypotheses interact with Verbal Reasoning Ability (unpublished).

Figure 5: A Case of the Preferential Model: Quantity of Uncertainty interacts with Dogmatism (Clark & Salomon, 1971).

Figure 6: A Case of the Preferential Model: Dull and Surprising Conditions in Interaction with Richness of Educational Background (Marshal, 1969).

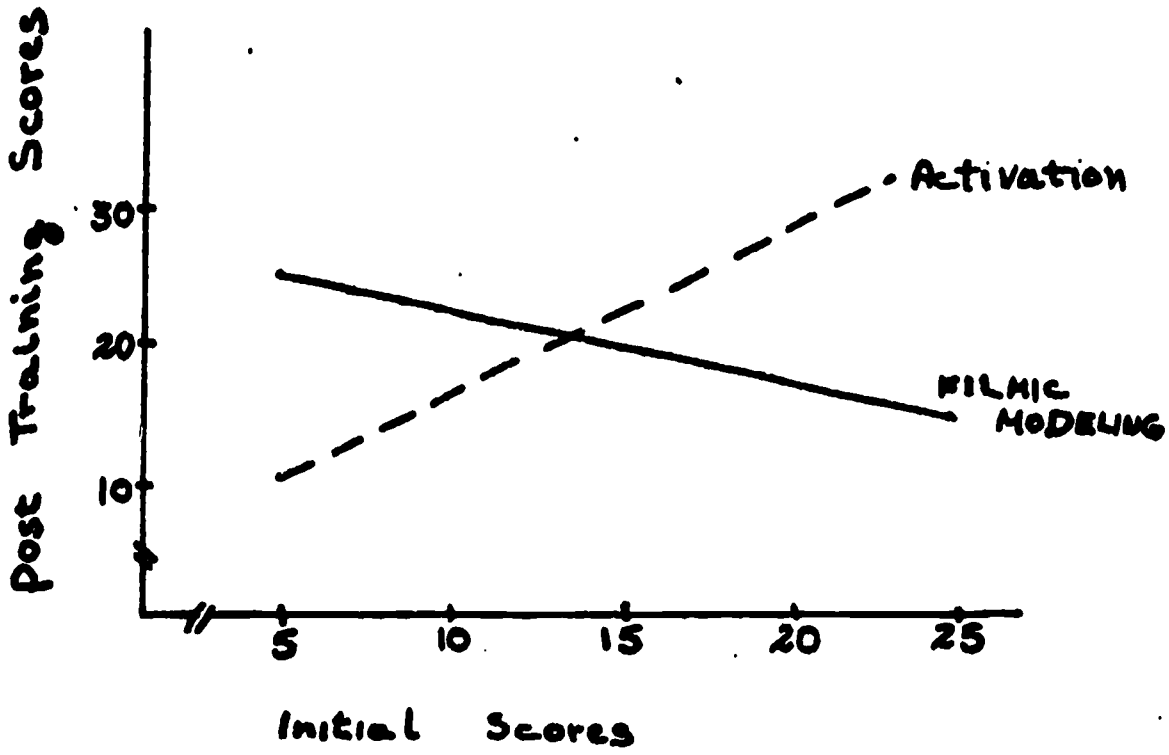
Footnotes

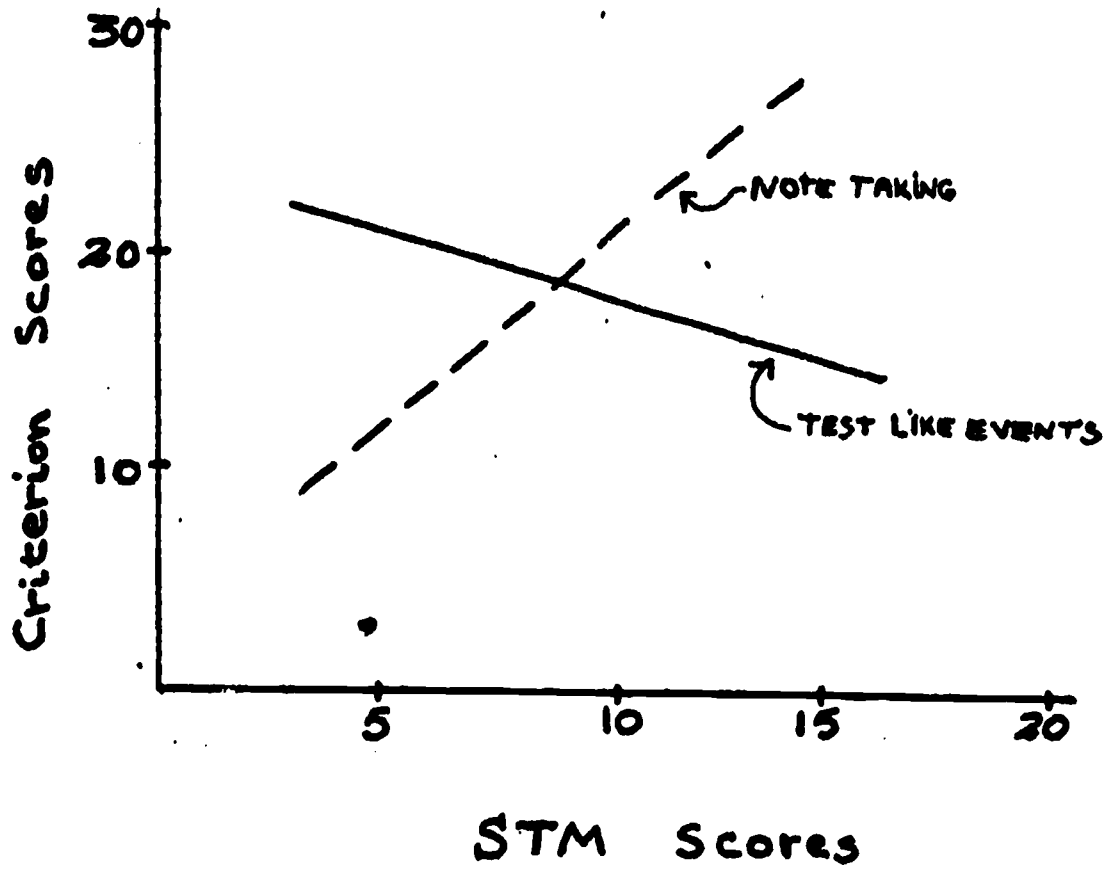
[1] In his program, labeled SOCRATES, Stolurow could predict each S's successes for any size unit of material on the basis of regression lines, as well as improve predictions on the basis of performance outcomes.

Table 1: Summary of ATI heuristic models.

The Model	The Function of the Instructional Treatments	The Major Differences Between Treatments	The Kinds of Aptitude Measures Used	Predictions
Remedial	Treatments lead to mastery of necessary deficient subordinate objectives	Amount of time spent on reaching mastery; number of remedial instructional sessions.	Measures of task specific mastery. More general abilities are transformed into instructional objectives and are dealt with as if task-specific capabilities.	Proficient learners experience interference or boredom with accessive remediation; low proficiency learners benefit since they attain necessary subordinate objectives
Compensatory	Treatments provide the learners with the necessary mediators, organisation of material, modality and the like which they cannot provide for themselves; or to circumvert debilitating effects of certain psychological traits or states. It is not assumed that the deficiencies need to be remedied.	The extent to which treatments provide overtly what learners would have to provide for themselves; or the extent to which they neutralize the effects of certain traits or states.	Measures of general abilities, modes of information processing, general states or traits.	High aptituders experience interference when given treatments which provide them with mediators they can provide on their own; Low aptituders benefit when mediators they are lacking are provided overtly.

The Model	The Function of the Instructional Treatments	The Major differences Between Treatments	The Kinds of Aptitude Measures Used	Predictions
Preferential	Treatments call upon and utilize learners' higher aptitudes, neither making up for deficiencies nor compensating for them.	Differences may be in content, structure, modality of presentation, etc. Each alternative treatment plays on aptitude in which the learner is more proficient.	Measures of general abilities modes of information processing or motivation.	Each Learner learns best when an aptitude- in which he is proficient - is called upon


Post Training Scores
30
20
10
Activation
FILMIC MODELING
5
10
15
20
25
Initial Scores


30
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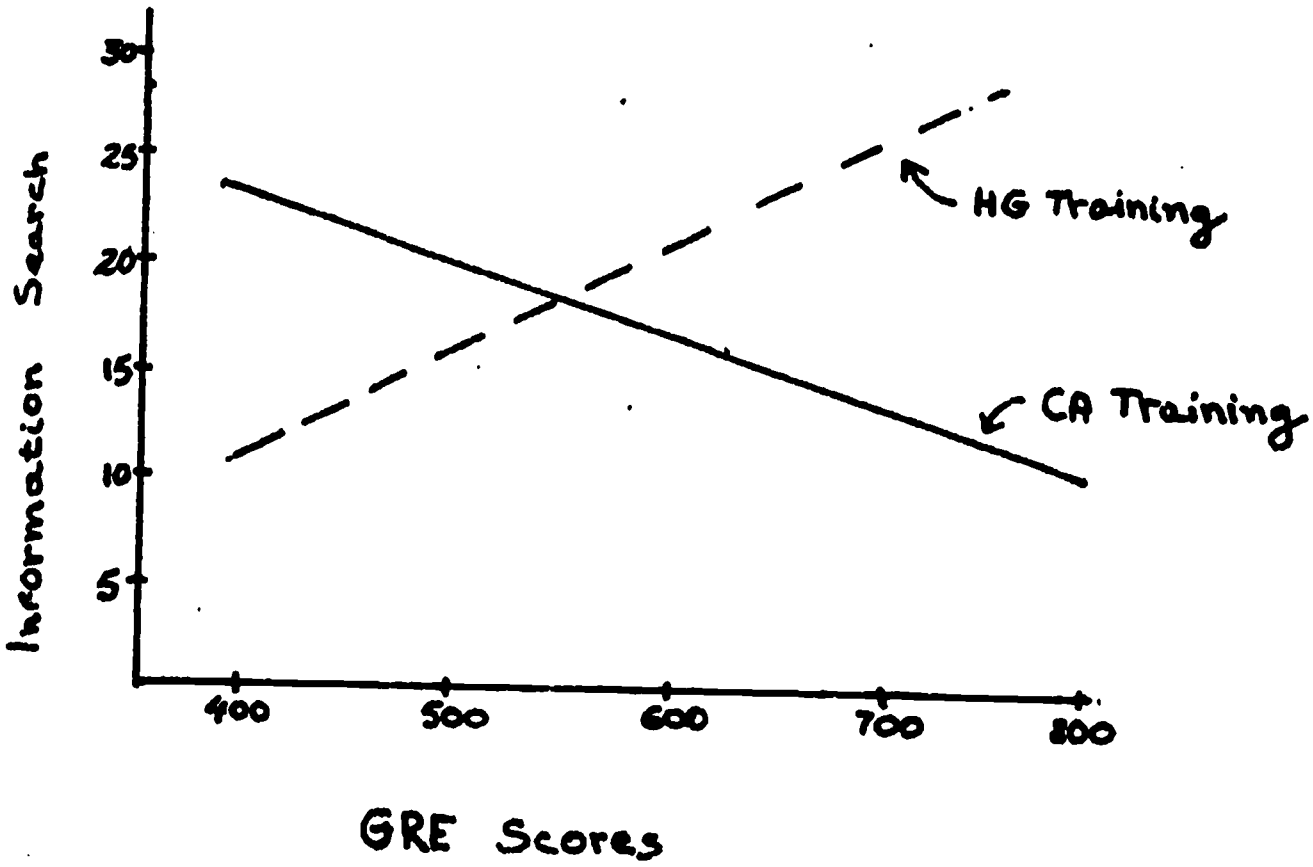
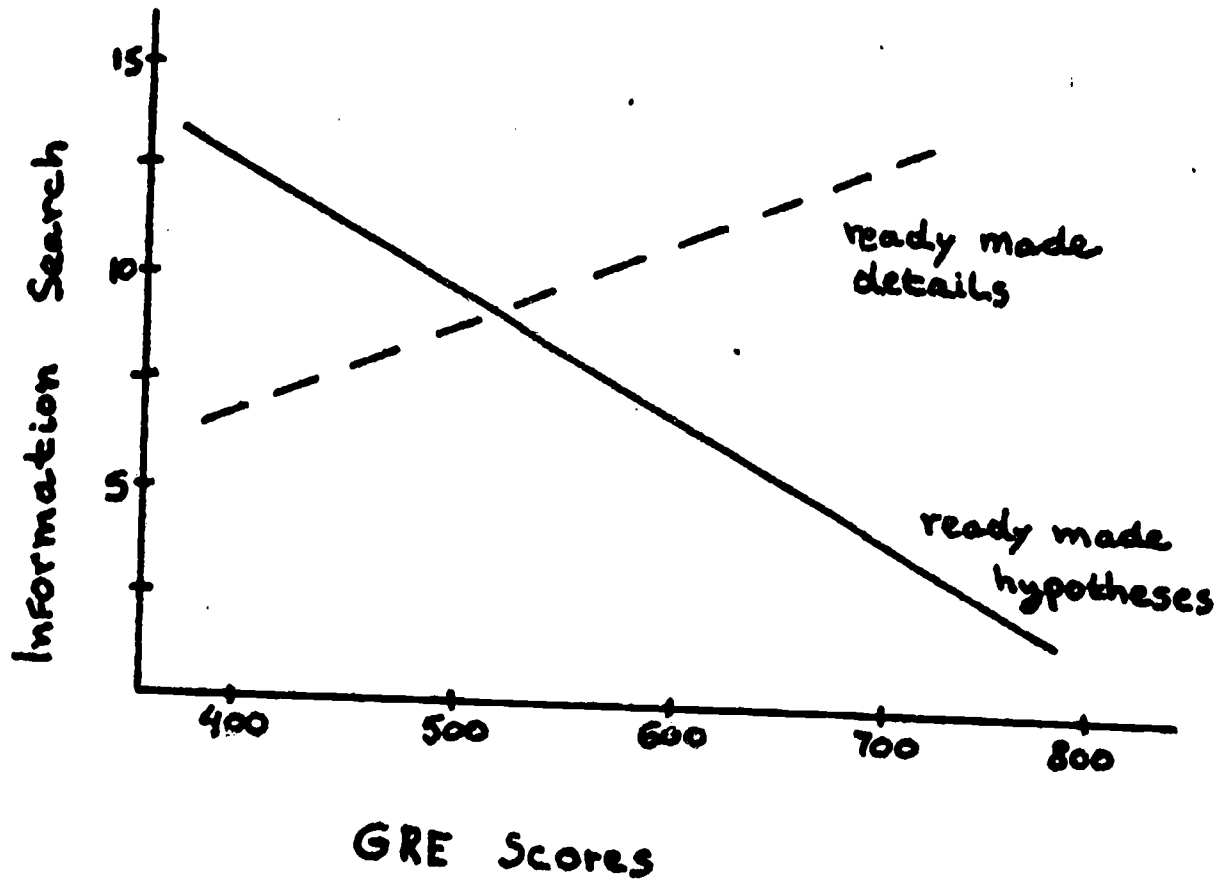
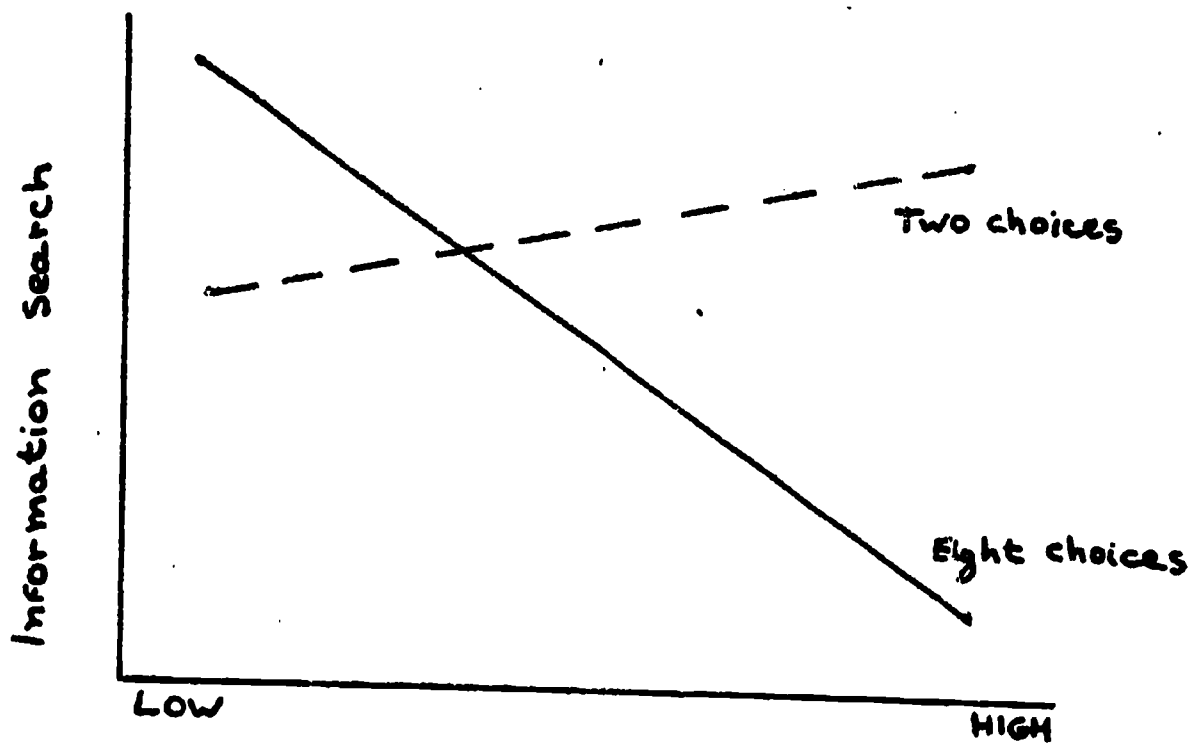
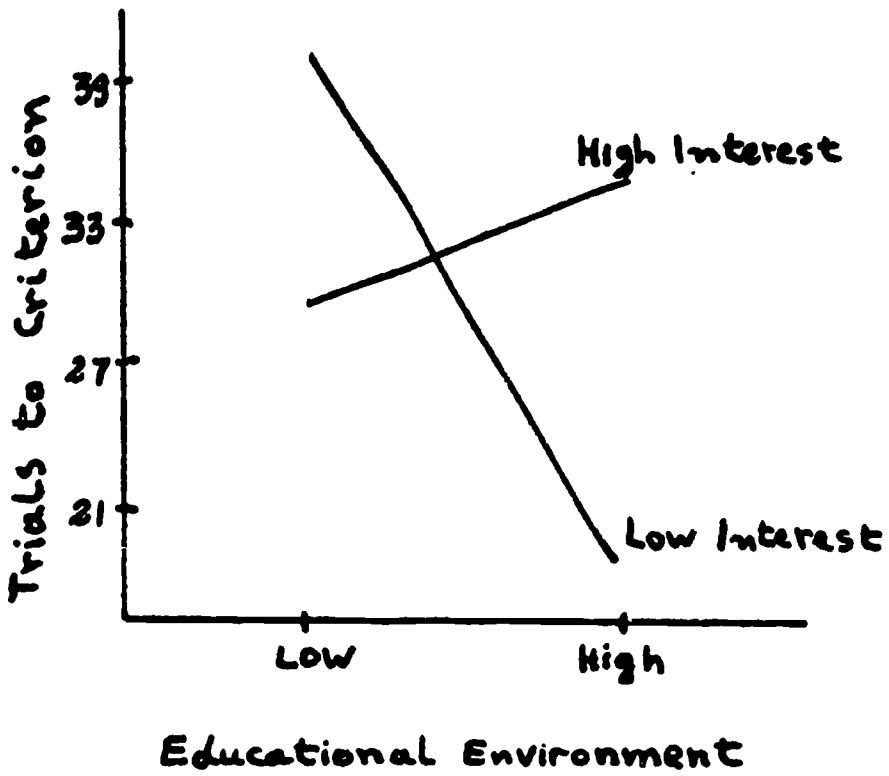
Criterion Scores
NOTE TAKING
TEST LIKE EVENTS
5
10
15
20
STM Scores


Information Search
30
25
20
15
10
5
400
500
600
700
800
HG Training
CA Training
GRE Scores


Information Search
15
10
5
ready made details
ready made hypotheses
400
500
600
700
800
GRE Scores



Dogmatism (D)


Trials to Criterion
39
33
27
21
High Interest
Low Interest
LOW
High
Educational Environment